



The PMI Advanced
BET SORPTOMETER
BET-201A-20S

Not just products...solutions!

DESCRIPTION

PMI's BET-Sorptometer is fully automated, volumetric gas sorption analyzer to measure accurately adsorption and desorption isotherms for the characterization of surface area, pore size distribution, pore volume and pore structure of micro and mesoporous materials as well as the kinetics of adsorption.

APPLICATION

PMI's BET Sorptometer has a multitude of applications in industries worldwide. Some applicable industries include

- Catalyst and Carbon
- Oil & Gas Industry/Geoscience
- Battery/Fuel Cells Industry
- Chemical Industry
- Ceramic Industry
- Filtration Industry
- Paper Industry
- Pharmaceutical/Medical Industry
- Powder Metallurgy Industry
- Automotive Industry



PRINCIPLE

When clean surface is exposed to a gas, an adsorbed film forms on the surface. Adsorbed films also form on the surface of pores within a material and vapor can condense in the pores. At a constant temperature, the amount of adsorbed/condensed gas on a surface depends on the pressure of the gas. Measurement of the amount of adsorption/condensation as a function of pressure can give information on the pore structure. The PMI Sorptometers use gas adsorption/condensation to analyze pore characteristics. Further, measurement of pressure as a function of time provides the kinetics information of adsorption.

PHYSICAL ADSORPTION

Weak van der Waal's type interaction of molecules with a pore surface leads to physical adsorption. The Brunauer, Emmett and Teller (BET) theory of physical adsorption is normally used for analysis of adsorption data to compute surface area.

$$\frac{P}{W(P_0-P)} = \frac{1}{CW_m} \frac{C-1}{CW_m} \frac{P}{P_0}$$

Where:

W = amount of adsorbed gas

W_m = amount of gas adsorbed in a monolayer

P = gas pressure

P₀ = equilibrium (saturation) vapor pressure at the test temperature

C = dimensionless constant that depends on the temperature and the gas/solid system

When vapor pressure, P is low compared with P₀ (0.05 < P/P₀ < 0.3), the plot of [P/W (P₀ - P)] versus [P/P₀] is linear and the plot yields the magnitudes of C and W_m. The surface area S per unit mass, m, of the sample is computed using the cross-sectional area of the adsorbed gas molecule:

$$S = \frac{W_m N_o a}{m}$$

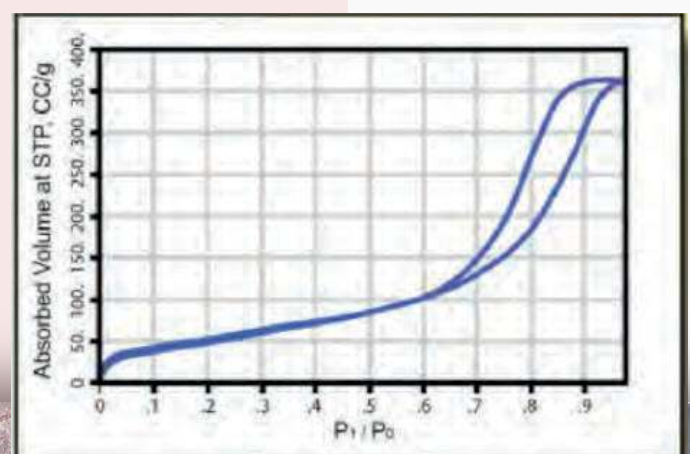
Where:

N₀ = Avogadro's number

a = cross - sectional area of the adsorbed gas molecule

W_m = amount of gas adsorbed in moles

Figure 1
Adsorption and Desorption
Isotherms at Liquid N₂ temperature



VAPOR CONDENSATION

As the relative vapor pressure (P/P_0) increases, vapor eventually condenses in the pores utilizing the surface free energy available due to replacement of the solid/vapor interface by solid/liquid interface. The amount of vapor condensed in pores gives the pore volume, and the Kelvin equation gives the pore diameter.

$$\ln \left(\frac{P}{P_0} \right) = - \frac{4 \gamma V \cos \theta}{DRT}$$

Where:

γ = surface tension of condensed liquid D = pore diameter

V = molar volume of condensed liquid R = gas constant

θ = contact angle T = absolute test temperature

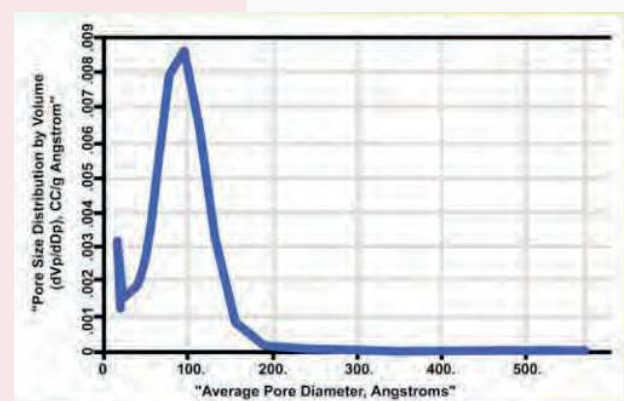
Adsorbed layers of molecules form on the pore walls before condensation fills the pores. Therefore the actual pore diameters are computed by adding two times the thickness of the adsorbed gas layer to D .

A complete adsorption isotherm is determined by measuring the amount of vapor adsorbed as a function of increasing pressure. A desorption isotherm is determined by measuring the amount of adsorption as a function of decreasing pressure. Based on this technique, characteristics of materials related to adsorption, desorption, surface area and pore volume can be determined.

PORE VOLUME & PORE DIAMETER

Pore volume, pore diameter and pore volume distribution can be determined accurately by the PMI BET Sorptometer. The distribution function is such that area under the function in any pore diameter range is the volume of pore in that range.

Figure 2
Pore Volume Distribution



ADSORPTION & DESORPTION ISOTHERM

Adsorption and desorption of gasses on samples can be accurately measured using our BET Sorptometer. The user has independent control over the quantity and spacing of pressures used in both adsorption and desorption testing. Many different kinds of analyses are available to interpret data using the supplied report generation software.

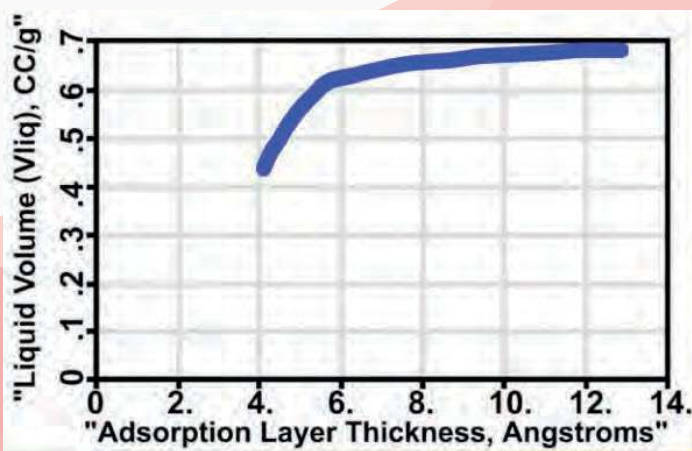


Figure 3

T - Plot Method - Micropore Volume Analysis

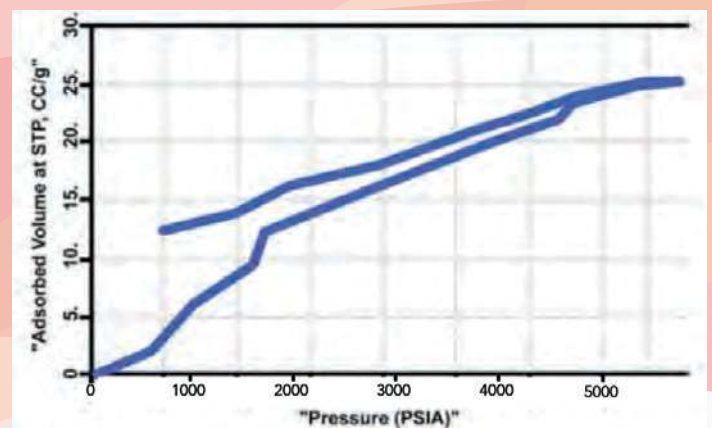


Figure 4

Adsorption and Desorption Isotherms
Water Vapor at 0°C

Pore Structure Characteristics:

- Mean Pore Size
- Pore Size Distribution
- Total Pore Volume
- Single Point Surface Area
- Multi-Point Surface Area
- Adsorption & Desorption Isotherms

SAMPLE CHARACTERISTICS

- Pore Size Range: 3.5 Å – 500 nm
- Surface Area Range (in m²/g): 0.0005 (krypton) to no known upper limit
- Surface Area Range (in m²/g): 0.01 (Nitrogen) to no known upper limit
- Micropore Volume (min): 0.0001 cc/g
- Dead-end & Through-pores
- Adsorption Temperature: -195.6°C (Liquid Nitrogen)
- Power Requirements: 110/200 VAC, 50/60 Hz

SPECIFICATIONS

- Continuous saturation pressure measurement capability.
- Oil-free high vacuum system for analysis.
- Separate oil-free high vacuum system for degas.
- Capability for all common analysis gases: N₂, Ar, Kr, CH₄, CO₂, H₂, CO, NH₃ and other non corrosive gases
- Isotherm: Upto Unlimited data points(per station), adsorption and desorption, Hysteresis plot
- Gas Inlet Ports: 5
- Pressure Measurement Ranges & Resolutions:
 - Low: 0 to 0.1 mm Hg Transducer (typical): 0.0000001 mmHg resolution
 - Medium: 0 to 10 mm Hg Transducer (typical): 0.00001 mmHg resolution
 - High: 0 to 1000 mm Hg Transducer (typical): 0.001 mmHg resolution
- Only one transducer to be used at any time; the same transducer used for measuring the dosed gas pressure is also used for measuring the equilibrated pressure.
- Dedicated pressure transducer for continuous P₀ monitoring.

Safety features:

- Non destructive testing.
- Quartz Heating Mantles on all ports with over-temperature protection in degassing stations.

FEATURES

- Two (2) separate outgassing stations
- Temp Range: Ambient to 430°C (Deviation $\pm 8^\circ\text{C}$)
- Automated Control (manual control also possible)
- Display of full adsorption and desorption isotherms
- Built in test points and diagnostics features.
- Port Provided for connection to Mass Spectrometer (optional)

Measurement & Analysis Techniques:

- Single-point and multi-point BET surface area
- Adsorption and desorption isotherms
- BET surface area
- STSA
- DFT
- BJH
- Langmuir surface area
- BJH Mesopore volume and area
- Total pore volume
- deBoer t-Plot
- MP-method
- Micro pore volume and surface area
- Micro pore Size Distribution
- α_s Plot
- NLDFT
- QSDFT
- Monte-Carlo
- DR and DA method
- Software is MS Windows Compatible (Windows 7 or Windows 8)
- Smart gas dosing system.
- Dewar Lifter with Feedback Loop to maintain cryogen level on sample tube.
- Software Controlled Two Sample Outgassing System (allows multiple temperatures, ramp rates and degas times to be programmed)

DATA SUPERVISION & ACQUISITION SYSTEM

- Automated Control with Data Collection and ability to export data to MS Excel or other Programs for report generation
- User friendly software that calculate data and also offers detail graphical representations.
- Certified Reference Standards will be supplied with the Unit for Various Surface Area for Physisorption & Chemisorption parameters evaluation.
- Original software of both physisorption and chemisorption provided
- Software for calculating surface area, pore size distribution and associated parameters under different available standard models/approximations.
- Provision for off -line data processing
- Provision for software upgradability available for free of cost.



Figure 5
Software Main Screen

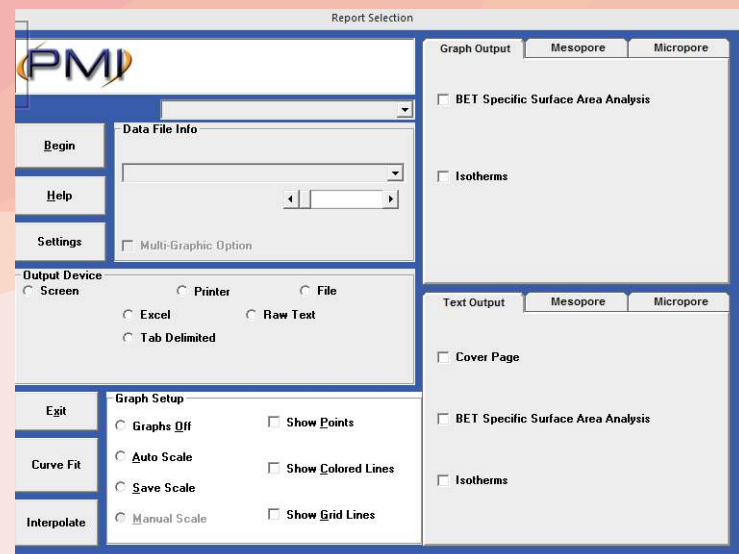


Figure 6
Report Selection Screen

SALES & SERVICES

We at Porous Materials Inc., have dedicated sales team helping thousand's of our customers identify the right solution for their scientific problems. We are also proud to offer customized instruments for your unique needs. Our service and applications team is committed to effective support with short response times, we offer comprehensive range of solutions from new and customized systems, calibration and maintenance to testing services.

Explore more about us at www.pmiapp.com



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